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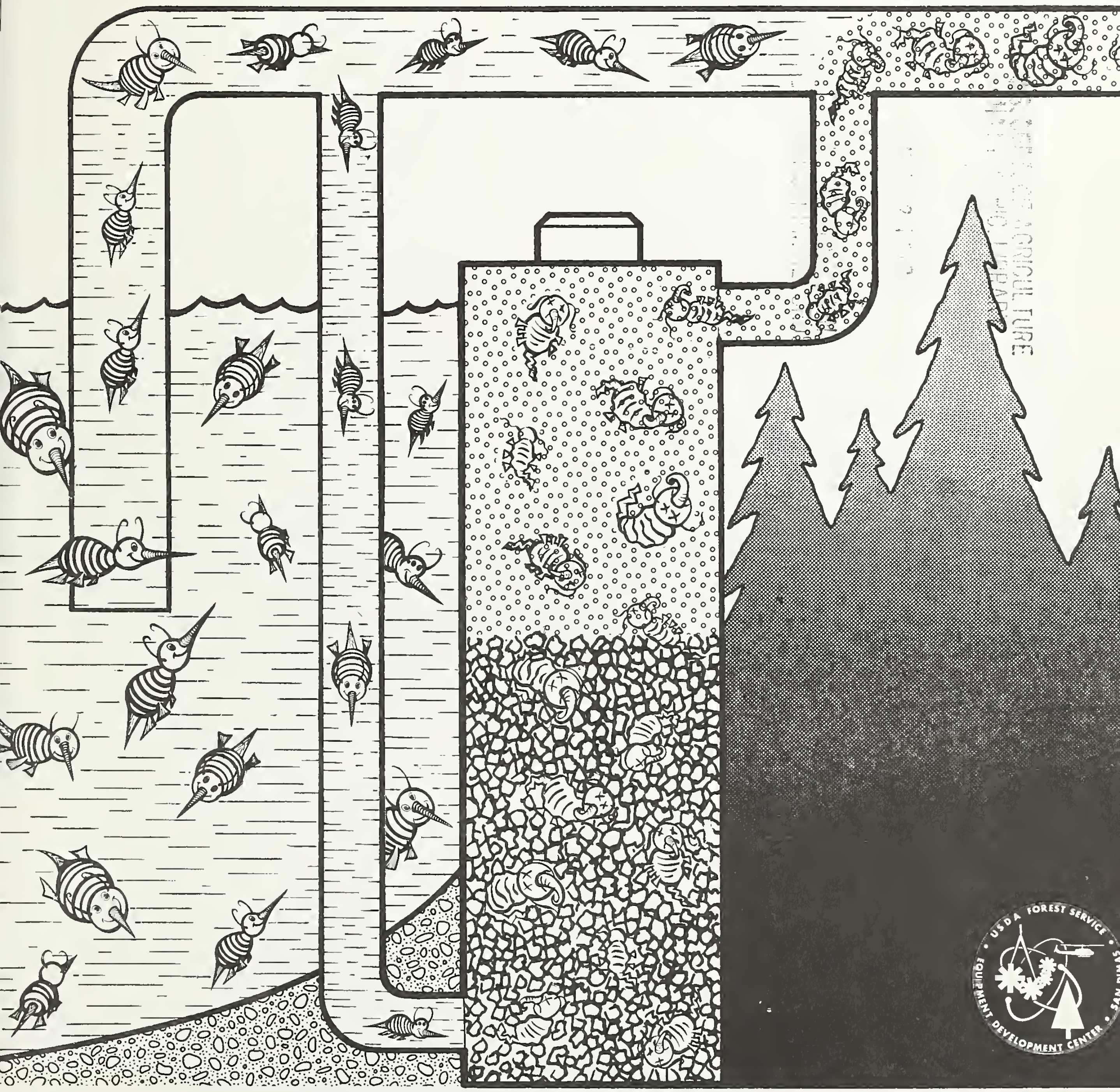

U.S. DEPARTMENT of AGRICULTURE FOREST SERVICE

EQUIPMENT DEVELOPMENT CENTER SAN DIMAS, CALIFORNIA

EQUIPMENT DEVELOPMENT AND TEST REPORT 7400-1

IODINE DISPENSER FOR WATER SUPPLY DISINFECTION

by

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ABSTRACT

Disinfection of remote spring-fed or hand-pump potable water supplies has long been a concern of the USDA Forest Service and other agencies, including the military services, faced with outdoor recreation/living situations. The environmental engineer at the San Dimas Equipment Development Center (SDEDC) has supervised inhouse and in-the-field tests of a commercially available disinfection unit, the Iodinator, that dispenses iodine into remote water sources. Findings to date indicate that iodine is an effective disinfectant and that an effective level of iodine can be provided, with very little dispenser maintenance necessary, in all types of water supplies, including spring-fed and hand-pump supplies.

The Environmental Protection Agency (EPA) and prominent endocrinologists have agreed (appendixes II, III, and IV) that concentrations up to 1.0 mg/l of free iodine in water supplies used for transient populations staying 3 weeks or less is acceptable.

KEY WORDS: Potable water, water supply disinfection, iodination, iodine dispenser.

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A report on ED&T Project No. 2438—Disinfection of Low-Flow Water Systems; Sponsored by Engineering, Water Pollution Abatement.

INTRODUCTION

The Forest Service utilizes a variety of water sources, ranging from wells and springs to surface water. Disinfecting many of these supplies presents physical, mechanical, or technical difficulties. Pressure and flow may be low; sites may be remote; electricity may be unavailable. Some disinfectant materials are corrosive; impurities in some disinfectants may cause stoppages in the feeder mechanism. These are just a few of the problems encountered. A potable water disinfection system is needed that can perform satisfactorily under adverse conditions with a minimum of attention.

Dr. A. P. Black studied an Iodinator (TM) for 3 years at penal institutions and found that it worked with an average water pressure of 40 to 65 psi. 1/ The Iodinator stores and dispenses iodine disinfectant contained in a compact plastic (PVC) cylinder which has no moving parts. The unit is manufactured by Iodinamics, subsidiary of the Continental Water Conditioning Corporation, 12400 Darrington Road, P. O. Box 26428, El Paso, Texas 79926.

The Iodinator was tested at·SDEDC from April to mid-November 1973 to determine whether a satisfactory level of iodine residual could be maintained at various water flows within a pressure range of ½ to 40 psi. In September 1974, a hand pump was used to test the Iodinator to determine if an effective disinfective residual of iodine could be maintained using this mode of obtaining potable water. The effectiveness of iodine as a virucide, bactericide, and cysticide already had been established (see the section that follows), and thus no tests along these lines were conducted by the Forest Service.

In August 1973, an Iodinator was installed at the Angeles Crest Station, Angeles National Forest, California Region; it is still functioning as evaluation of the unit continues. During the initial test period, ease of installation, durability, possible maintenance problems, and presence of objectionable taste or odor were monitored. Los Angeles County, as part of its regular testing of local water, evaluated the effectiveness of the installation as a bactericide.

IODINE AS A DISINFECTANT

Established Effectiveness

The following studies indicate that iodine is an effective virucide, bactericide, and cysticide:

"[In] 1953, Chang and Morris published their important studies which showed iodine's effectiveness against bacteria, viruses, and cysts . . . of Endameba histolytica. Their studies were primarily responsible for the adoption of iodine by the military for the disinfection of canteen water in the field." (1)

According to a 1955 study by Louis Gershenfeld (Director, Department of Bacteriology, Philadelphia College of Pharmacy and Science), "The effectiveness of iodine is detailed in the field of therapy and especially in the fields of prophylaxis and sanitation of many infections caused by viruses. The use of a suitable antiseptic for preparing the surface to be traumatized, either by injections or by operative procedure, is of great importance. Of the local antiseptics tested, iodine tincture was found to be most effective in quickly destroying the poliomyelitis virus. In the author's laboratory, concentrations of free iodine, as may be used in preparing a mouthwash, were found to be capable of destroying polio virus." (6)

1/ Black, A.P., Ph.D. 1974. Telephone conversation. University of Florida, Miami, Fla.

"Gershenfeld and Witlin concluded [that] bactericidal efficiency tests of the dilute halogens (1:5,000) revealed that free iodine solutions displayed more effective antibacterial activity against the test bacteria than did chlorine or bromine at 37 or 24°C, either in the absence or presence of organic matter." (5)

"Under poorly controlled circumstances, as present in village tanks that support the water supply of small communities, the low solubility of iodine, its good germicidal capability, and its relatively chemical inertness make it a suitable disinfectant. As compared with chlorine, iodine shows the advantage of the ease of handling, longer application under unsupervised conditions, wider pH range, and less susceptibility to interference from ammonia and organic substances in the water to be dosed." (9)

Table 1 lists the contact time required by 0.5 mg/l of iodine with a pH of 7.5 at 20 to 26°C to kill *all* the disease organisms listed. (7)

Table 1. *Effectiveness of iodine as a disinfectant*

BACTERIA	DISEASE CAUSED	CONTACT TIME
Escherichia coli	Cystitis of urinary tract	Under 50 seconds
Salmonella typhosa P-4	Typhoid fever; gastro-enteritis	1 minute
Salmonella typhosa P-5	Typhoid fever; gastro-enteritis	1 minute
Salmonella typhosa P-10	Typhoid fever; gastro-enteritis	1 minute
Salmonella paratyphi P-2	Paratyphoid fever	1 minute
Salmonella schottmuelleri P-3	Paratyphoid fever	2 minutes
Salmonella typhimurium P-6	Food poisoning	5 minutes
Shigella flexneri P-7	Paradysentery	2 minutes
Shigella dysentariae II P-8	Dysentery; intestinal ulcers	2 minutes
Shigella sonnei I P-9	Paradysentery	2 minutes
Streptococcus fecalis E-40	Can be pathogenic	2 minutes
Staphylococcus aureus	Septicemia, brain abscess, enteritis	50 seconds
Staphylococcus epidermidis	Subacute endocarditis	1 minute
VIRUS		
Poliovirus Type 1	Polio	Under 9 minutes
CYSTS (@ 1 ppm iodine)		
Entamoeba histolytica	Severe dysentery	Approx. 30 min.

Even though iodine has been proven to be an effective virucide, bactericide, and cysticide, some questions have been raised about possible physiological effects caused by drinking iodinated water. In researching this problem, the following studies were found:

In a 6-month test using military personnel (7), 24 subjects ingested an average of 14.8 mg of iodine per day through the water supply. Analysis of clinical tests did not reveal evidence of weight loss, failure of vision, cardiovascular damage, altered thyroid activity, anemia, bone marrow depression, renal irritation, skin disease, or sensitization to iodine among those consuming the iodinated water.

In the studies of A. P. Black and his associates (1), over a period of several years, the use of iodinated water was judged to have produced no detrimental effects to the general health or thyroid function of the subjects, a population of approximately 600 persons in Florida correctional institutions. Figure 1 shows the iodine concentration used and the length of the study.

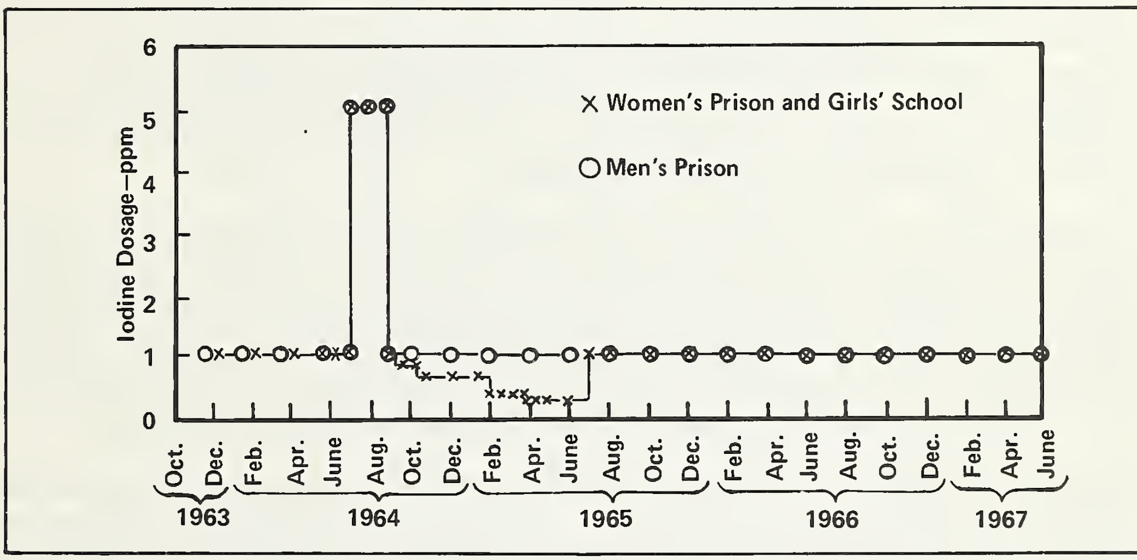

Figure 1 Iodine concentration in prisons' water supply (2)

The Iodine Committee of the American Thyroid Association at its annual meeting, St. Louis, Mo., September 18 through 21, 1974, adopted a statement on human iodine intake. In part, the statement reads "that steps be taken by federal agencies and individual investigators and laboratories to obtain the data necessary to make a sound recommendation on optimal limits for human iodine intake." (The full statement can be found in appendix I.) After the committee meeting, Dr. James A. Pittman (Chairman of the Iodine Committee) wrote a letter to the environmental engineer at SDEDC, expressing his opinion (see appendix II) that iodinated water supplies have not been harmful to those currently using them.

Dr. Lewis E. Braverman, M.D., Professor of Medicine and Chairman, Department of Endocrinology, University of Massachusetts Medical School (formerly of St. Elizabeth's Hospital of Boston and a former member of the Iodine Committee) also wrote a favorable opinion on using iodine for potable water disinfection at transient use (3 weeks or less) and small permanent use sites (see appendix III). Dr. Braverman is currently conducting clinical

studies in a few towns in New Mexico on the effects of iodinated water supplies on the thyroid function. Coincidentally, New Mexico currently has the highest per capita iodine intake in the country (8).

In February 1973, the Environmental Protection Agency (EPA) prepared a statement on the use of iodine disinfection of drinking water (see appendix IV). A summary statement from that letter includes the statement, "the opinion of experts in the field indicates that little if any hazard to consumers would exist if disinfection with iodine were practiced on those water supplies where the consumers are transient and use the water for drinking purposes for periods of three weeks or less."

General Properties

Of the four common halogens (fluorine, chlorine, bromine, and iodine), iodine is highest in atomic weight, least soluble in water (and least hydrolyzed by water), and lowest in oxidation potential. Iodine also reacts least readily with organic compounds. Iodine's low chemical reactivity means that an iodine residual in the water supply is more stable and thus persists longer in the presence of organic (or other oxidizable) material than a corresponding residual of any of the other halogens. Hence, the possibility that taste and odors will be produced by such reactions is minimized. Because iodine's vapor pressure is only 0.31 mm of mercury at room temperature, it can be stored indefinitely in nonmetallic containers at atmospheric pressure without appreciable loss or deterioration. As a comparison, water at $20^{o}C$ has a vapor pressure of 17.5 mm of mercury.

A saturated solution of iodine is used to control the amount of iodine residual in a water supply. The iodine saturation point of water varies with water temperature (fig. 2). At a constant temperature, only a finite amount of iodine dissolves in water, regardless of how long the contact time. Once the water has become saturated and is out of contact with the iodine crystals, a further temperature change has no effect on the concentration. A rapid, sensitive, and accurate colorimetric method has been developed for the determination of iodine residual in water in the presence of free and combined chlorine (see appendix V).

The disinfecting qualities of iodine and chlorine are affected by the pH of the solution, but iodine is more effective through a wider range of pH. Table 2 shows the effect of pH on the hydrolysis of iodine and chlorine, assuming an initial concentration of 0.5 mg/l. Hypochlorous acid (HOC1), free available chlorine residual, is formed by the reaction of chlorine (Cl_2) with water and is the most effective form of chlorine for disinfecting. As the pH increases, hypochlorite ions (OCl^-),which are relatively ineffective in water disinfection, are formed in increasing amounts.

Elemental iodine (I_2) is very effective as a water disinfectant. As the pH increases, I_2 reacts with water and forms hypoiodous acid (HIO), which is bactericidally effective. At high pH levels, a trace of hypoiodate ions (IO^-), which is ineffective as a bactericide, is formed. Other tests conducted by Chang and Morris (4) showed no difference in bactericidal efficiency using pH values from 4.5 to 10.0.

Iodine, when heated, reacts vigorously with reducing materials, but is not a fire hazard and there is no danger of explosion (9). The toxic hazard rating for iodine is greater than for hypochlorites (9) but, because solid elemental iodine has low volatility at room temperature, an open container of iodine crystals is much less irritating to the eyes, nose, and throat than are dry powder hypochlorites.

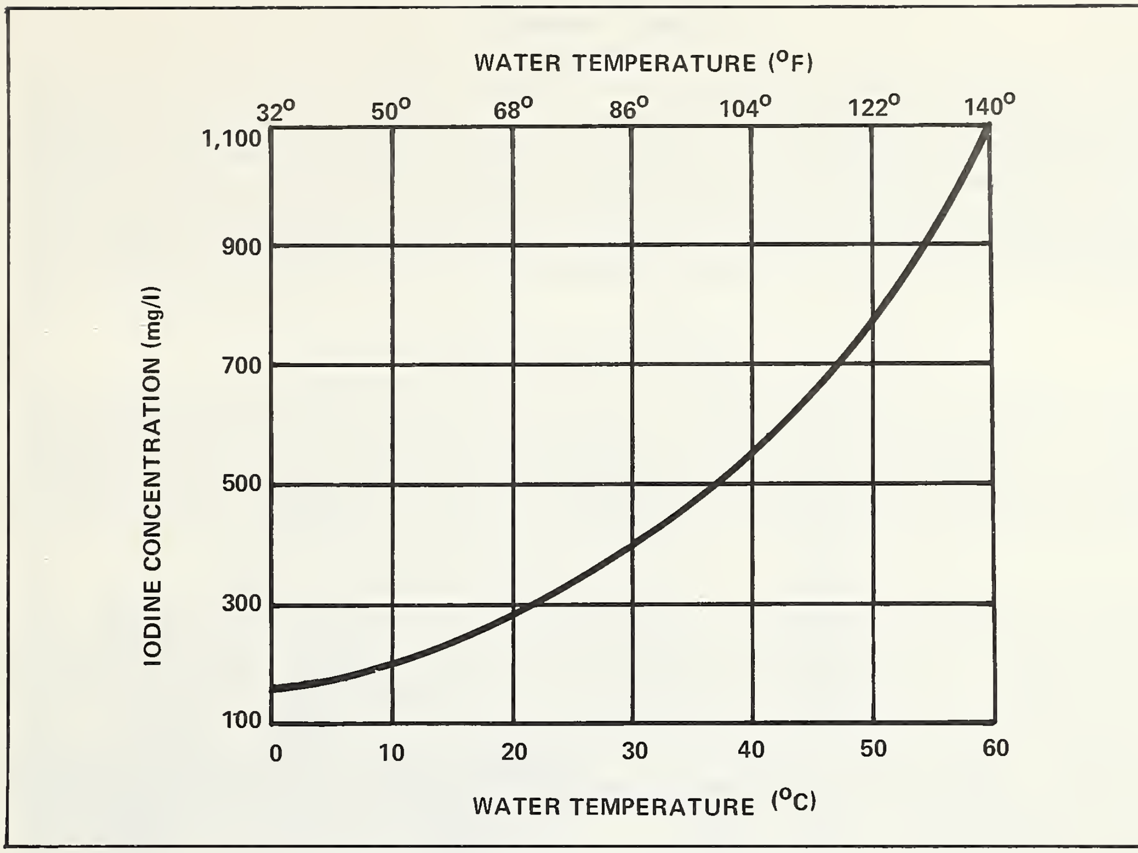

Figure 2. Solubility of iodine in water (1).

Table 2. *Effects of pH on hydrolysis of iodine and chlorine (1)*

CONTENT OF RESIDUAL (Percent)				CONTENT OF RESIDUAL (Percent)			
pH	I_2	HIO	IO	pH	Cl_2	HOCl	OCl
				4	0.5	99.5	0
5	99	1	0	5	0	99.5	0.5
6	90	10	0	6	0	96.5	3.5
7	52	48	0	7	0	72.5	27.5
8	12	88	0.005	8	0	21.5	78.5
				9	0	1.0	99.0

Safety Precautions

Safety precautions commonly observed with chemicals should be taken. Safety instructions supplied with the equipment and the iodine crystals should be followed closely. Iodine crystals should be stored in a cool, dry place, in containers supplied with the iodine crystals. Iodine vapors are highly corrosive to most metals and discolor all organic material. Rubber gloves should be worn when handling the iodine crystals to prevent discoloration of the skin. Skin irritation and discoloration can be expected on short exposure; burns occur upon continuous contact of over 5 min. Care should be taken not to breathe concentrated fumes.

EQUIPMENT TESTED

The Iodinator (fig. 3) consists of a plastic (PVC) container tank, flexible tubing, fittings, two valves, and a supply of iodine crystals. Installation and operating instructions for the device appear in appendix VII. A test kit for the determination of free residual iodine is supplied with the Iodinator. The Iodinator is available on a GSA FSS schedule: contract GS-00S-30865 through October 31, 1976, FSC class 4610, group 46, part I, section A.

The Iodinator comes in sizes ranging from 1-lb units (capable of treating a total of 241,000 gal of water at 0.5 mg/l) up to 200-lb units (capable of treating a total of 48 million gal of water at 0.5 mg/l). The manufacturer will supply the proper size Iodinator when advised of the maximum and minimum flow conditions at the use site. The Iodinator is advertised to withstand a constant pressure of 100 psi, and an intermittent pressure of up to 150 psi. Each unit is currently tested by the manufacturer at 200 psi. The iodine crystals are composed of elemental iodine guaranteed to be 99.5 percent pure.

The model tested at SDEDC, the 124-8, measures 4½ in in diameter and is 12 in high. It holds 8 lb of iodine crystals and is capable of treating a total of 1,929,000 gal of water at 0.5 mg/l. Approximately 270,000 gal of water, using various iodine concentrations, were used during the test.

Costs of the equipment are moderate. The price of an 8-lb unit (including one filling of iodine crystals) is presently quoted by Iodinamics at $267. The 5-lb unit costs $198. Crystals for replenishment of the Iodinator cost $11.95 per lb. There is a discount schedule listed in the GSA contract.

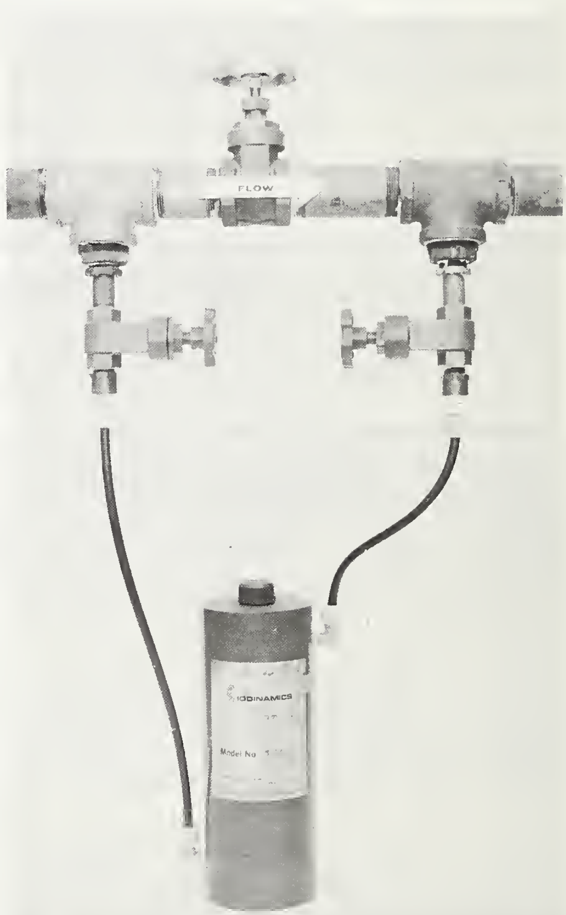

Figure 3. Typical Iodinator installation.

Low- and High-Pressure Tests

The Iodinator was installed in two different test apparatus arrangements to test its effectiveness in both low (0 to 5 psi) and high (5 to 40 psi) ranges of water system pressure. In the low-range pressure tests, a 50-gal drum was attached to a chain hoist and fitted with a toilet tank float control assembly to maintain a static head. A ¾-in hose supplied water to the 50-gal drum from a 50-psi industrial line. A filter with noncompacted activated carbon was

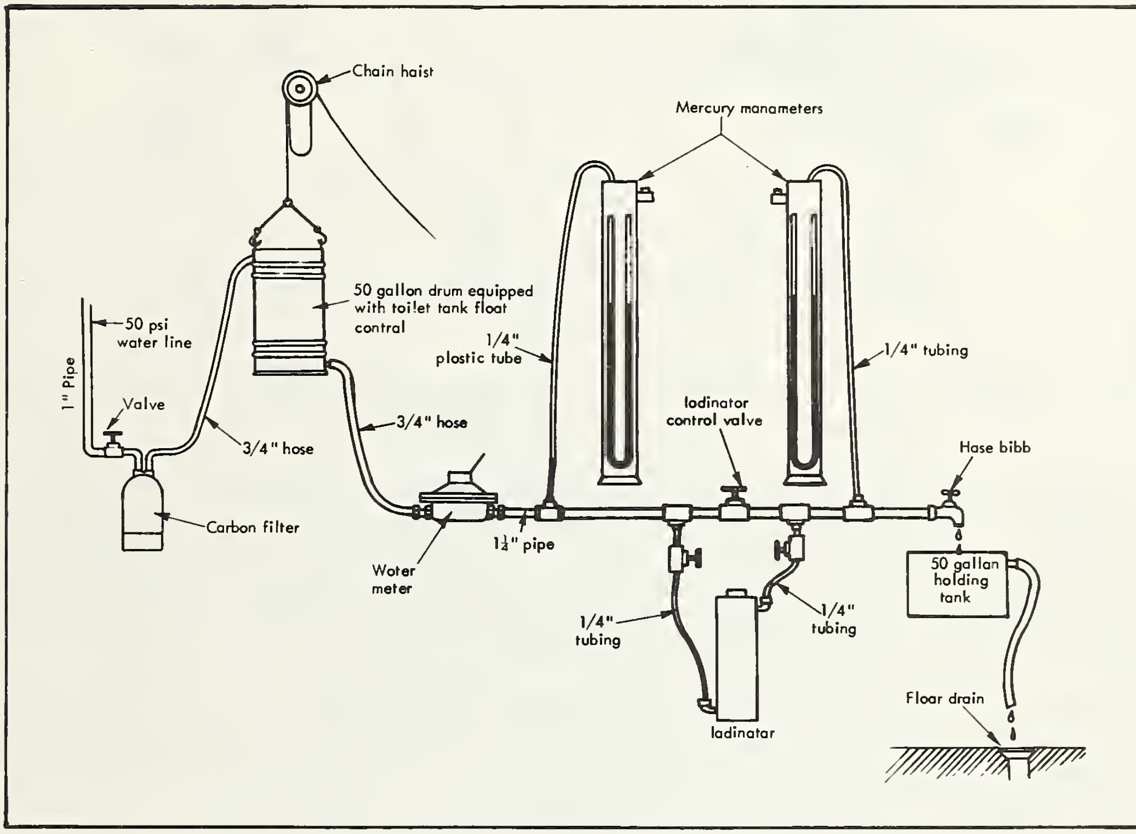

Figure 4. Test apparatus for low-pressure test.

installed in front of the 50-gal drum to remove any free or combined chlorine residual present in the water supply. Following the 50-gal drum was a water meter, a mercury manometer (range of 0 to 12 psi), the Iodinator, a second mercury manometer, a ¾-in hose bibb, and a 50-gal holding tank (fig. 4). The mercury manometers were installed to record the varying pressures in the system and the pressure drop across the Iodinator. The 50-gal drum was raised and lowered to vary the static head, and the hose bibb was regulated to produce various flows.

In the high (5 to 40 psi) range, a ¾-in industrial water supply line (capable of 50 psi) was followed by a filter with noncompacted activated carbon, a pressure gage (range of 0 to 100 lb in 1-lb increments), the Iodinator, a second pressure gage, a hose bibb, and a

50-gal holding tank (fig. 5). The pressure in this system was adjusted by the gate valve before the carbon filter and by the hose bibb at the end of the system. The pressure drop across the Iodinator during both test conditions was not readable; for practical purposes this can be considered negligible.

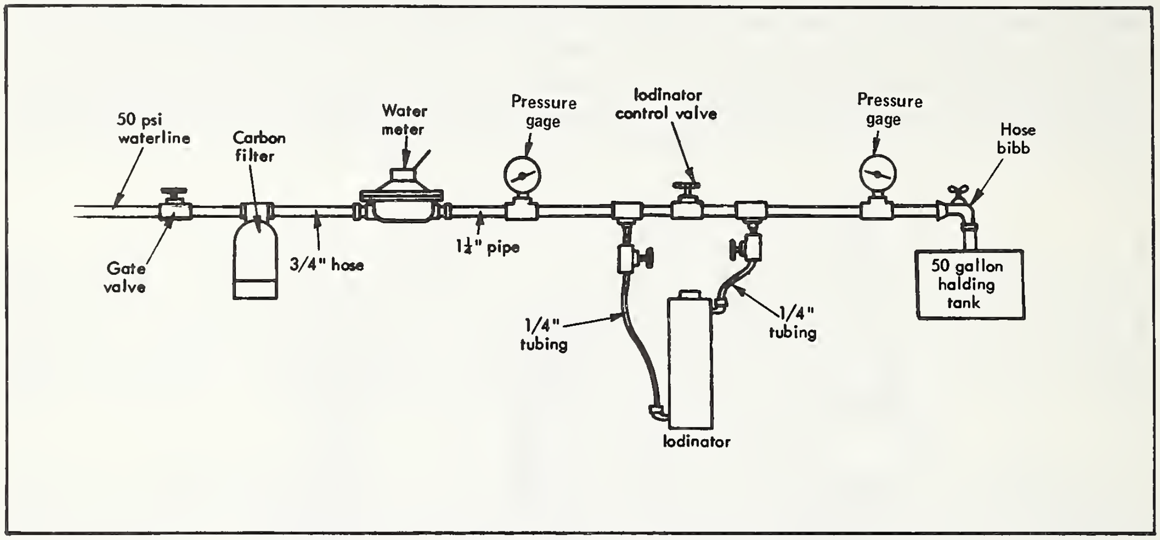

Figure 5. Test apparatus for high-pressure test.

The Iodinator was first tested in the low (0 to 5 psi) range to see if a constant iodine residual would be maintained if the head was varied while the flow was kept constant. The heads were set to produce pressures of ½, 1, 1½, 2, 2½, 3, 3½, and 4 psi. The flows varied from 1 to 2½ gpm. The Iodinator was then tested to determine if a satisfactory iodine residual between 0.5 and 1.0 mg/l could be maintained when the head was kept constant and the flow was varied. Flows tested ranged from near 0 to 5 gpm.

For tests in the high (5 to 40 psi) range, pressures were regulated for intervals between 10 and 40 psi, with flow settings ranging from near 0 to 11 gpm. Again, the intent was to determine if the iodine residual would remain constant over a wide range of pressure and flow conditions.

The test for free residual iodine was performed as often as four times an hour, but usually tests were made between five and ten times a day. The iodinated water supply was often tasted at various concentrations of iodine to determine if it was offensive.

Hand Pump Test

A model DF-HT Monitor pump stand from Baker Manufacturing Co., Evansville, Wis. 53536, was used to test the Iodinator. This model is specifically designed to be used with an attached disinfection system. When an existing hand pump cannot accommodate an Iodinator, adaptor blocks can be purchased from Iodinamics. The hand pump (fig. 6) was first pumped between 30 to 40 strokes a minute and then it was tested using approximately 80 strokes a minute. The hand pump was mounted on a 600-gal steel tank full of water.

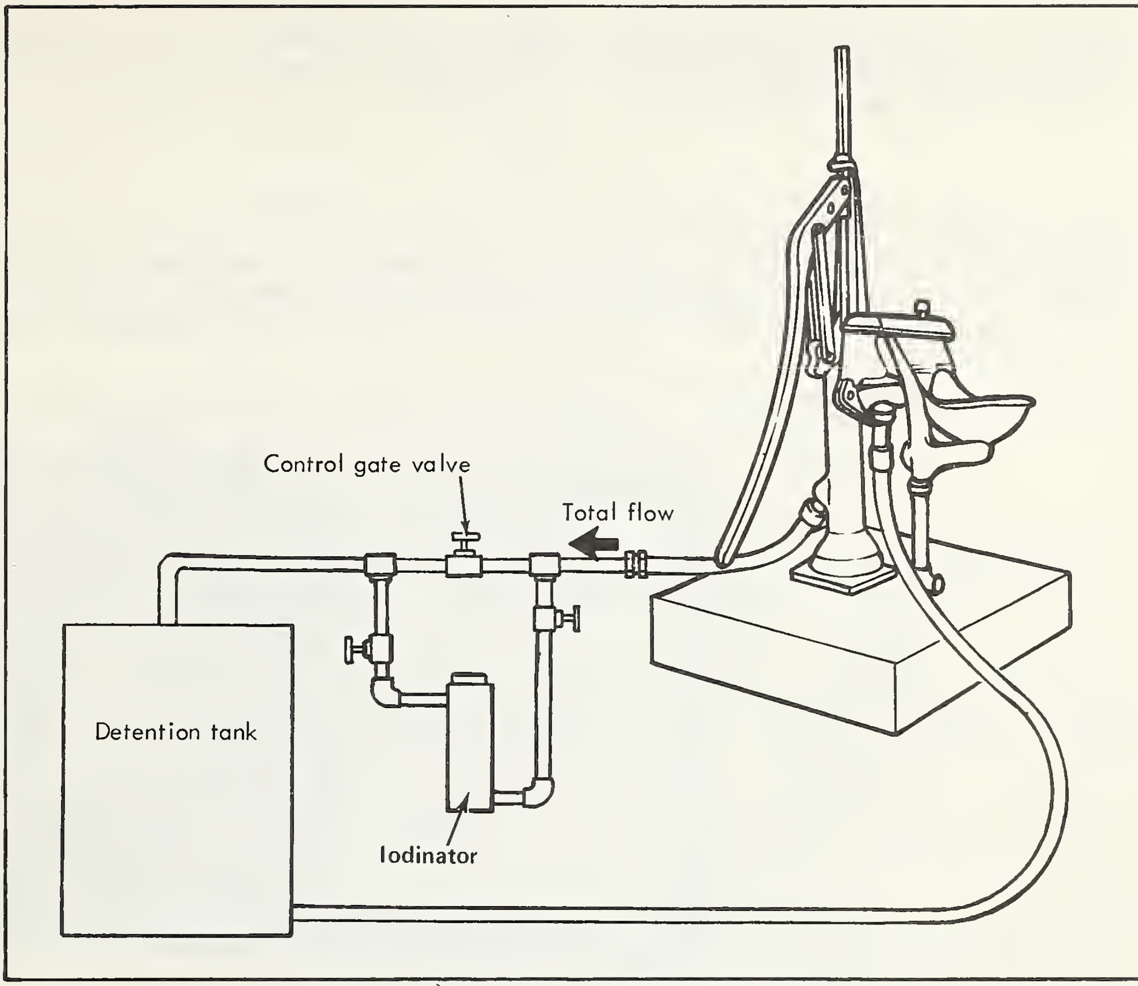

Figure 6. Typical hand pump installation.

The Iodinator was set for a residual iodine concentration between 0.7 and 0.8 mg/l. Readings of iodine residual were taken during constant pumping and also after the pump sat idle for various time intervals from 5 min to overnight. In each case, the iodine concentration was uniform after approximately three steady strokes of the handle.

FIELD TEST

Test Site

The Angeles Crest Station on the Angeles National Forest was selected for the field installation. This water system supplies drinking water to the recreation public on their way up the Angeles Crest Highway, as well as to Forest Service employees, who were informed of precautions to be taken pertaining to iodine intake per Pittman's statement (third paragraph, appendix II). Recent high coliform readings in the water supply caused the County sanitarian to request that this system be disinfected. SDEDC needed a test site and the Forest needed a disinfection system, so this location was chosen. Other test conditions we sought were also present at this site: water supply was spring-fed; it has low pressure and low flow; and no electricity was available near the Iodinator location.

The water system is supplied by a spring located approximately 3 miles uphill from the Station. The water runs constantly, overflowing at two 10,000-gal and one 5,000-gal holding tanks located above the Station. The storage tanks were not used as iodine detention tanks because the water overflow would result in a waste of iodine.

Test Equipment

A model 123-5 Iodinator (capable of disinfecting 1,206,000 gal of water at 0.5 mg/l) was installed on the 2-in galvanized line following the storage tanks. Immediately after the Iodinator, a 2-in float control valve was installed on a 450-gal stainless-steel tank (fig. 7). This float valve has a quick on/off feature that assists in maintaining constant water flow through the Iodinator.

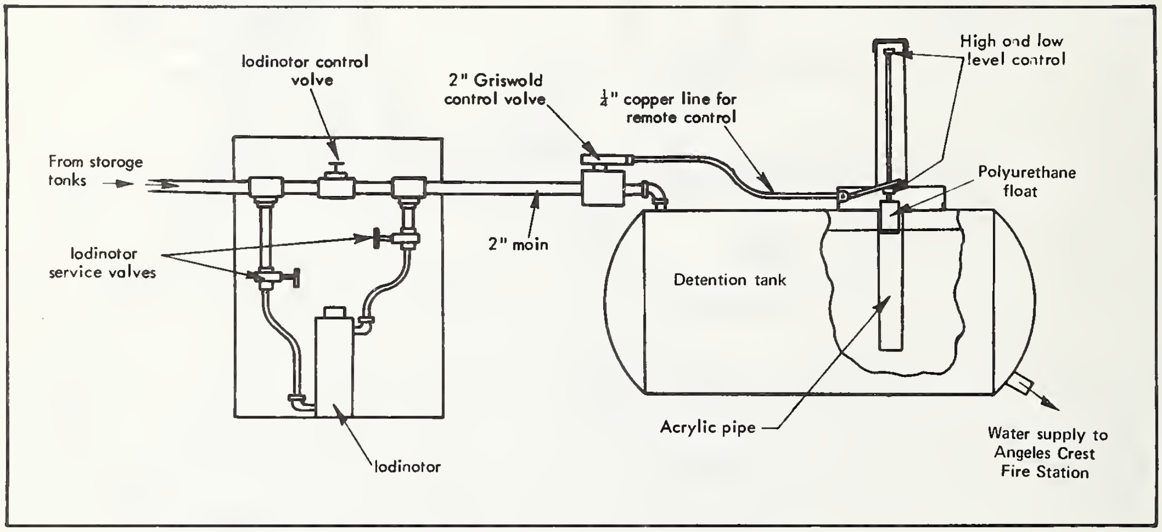

Figure 7. Field installation of the Iodinator.

The stainless-steel detention tank was surplus at the Center and larger than actually needed, but it was used anyway; however, the detention tank should be designed for a minimum 20-min contact time. Iodine is noncorrosive at normal use concentrations (0.5 to 1.0 mg/l), so any metal, wood, or concrete tank is acceptable.

After installation, the Iodinator required approximately 10 min to adjust for a 1.0 mg/l residual iodine concentration. The Iodinator requires seasonal adjustment in this location to compensate for water temperature changes because the supply line from the spring to the storage tanks is exposed for 3 miles.

The manufacturer suggests that the iodine crystals be checked each year and replenished when two-thirds depleted. The only other maintenance procedure is adjusting the Iodinator when the water temperature changes or when there is a flow change for a significant period of time.

Sampling Procedure

When potable water supplies are sampled for a coliform count, the bottles are usually

pretreated with sodium thiosulfate (a halogen neutralizer) to prevent further disinfection by any chlorine remaining in the water sample. This allows the water supply to be examined as the user would receive it. As this procedure has the same effect on iodinated water, no changes or additional precautions are necessary.

Two test kits are available for determining iodine concentration; both use leuco crystal violet as an indicator. The kit supplied with the Iodinator (fig. 8) consists of a 10-ml cylindrical glass tube, small plastic dropper bottles (one containing leuco crystal violet and the other a citrate buffer solution), and a paper color comparison chart. Various shades of purple indicate concentrations of from 0 to 1.5 mg/l residual iodine.

An alternate test kit (fig. 9) uses a combination of three chemicals to indicate either free residual iodine or total iodine (iodine plus iodide). A buffer solution is used with the

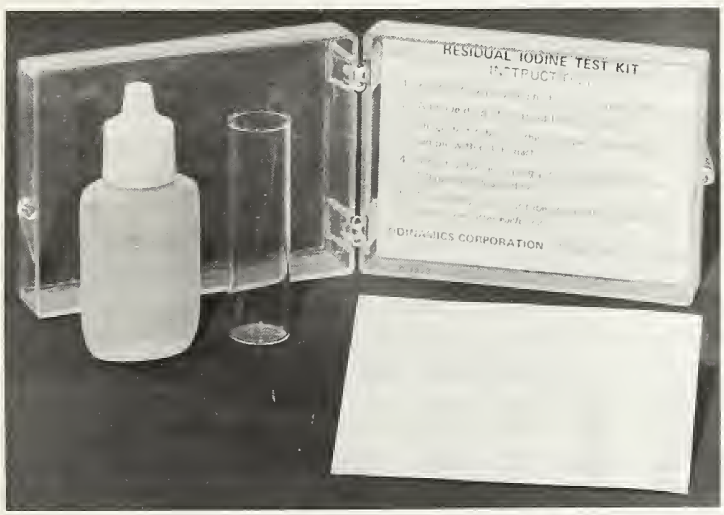

Figure 8. Simple test kit supplied with the Iodinator.

Figure 9. Alternate test kit. **(Available for relatively precise determination of iodine residuals in the presence of chlorine.)**

leuco crystal violet indicator to determine free residual iodine; for total iodine, a third solution is added to the sample (see appendix VI).

Iodine residuals in water containing free and combined chlorine can be determined with this kit, which uses a color comparator block containing liquid color samples sealed in plastic. The various shades of purple indicate concentrations from 0 to 2 mg/l. The kit includes a rectangular molded plastic 15.5-ml cell, and a small sponge cell cleaner.

Brushes, soap, and distilled water were used between tests to clean glassware and plasticware to assure that no residual iodine was carried over from one test to another. The plastic cell in the alternate test kit tended to accumulate a purple stain, so the cell was cleaned periodically with a strong chlorine concentrate, and then rinsed thoroughly with distilled water.

TEST RESULTS

In both application and field testing, favorable results were observed. The Iodinator produced a constant free iodine residual through the test range of pressures from ½ to 40 psi, as long as any combination of pressure and flow rate remained the same. Each water supply will vary in its initial iodine demand, depending on the amount of interfering substances in the supply. At first each Iodinator installation will require a period of trial-and-error adjustment to obtain a satisfactory iodine residual.

Certain procedures were found to be necessary to obtain favorable results. If the Iodinator regulating valve on the main water line remains at a constant setting, and the water supply head remains static, a varying flow produces varying concentrations of residual iodine. At pressures below 5 psi, this effect is more noticeable than at higher pressures. All Iodinators should be installed to keep the pressure and flow across the Iodinator relatively constant.

If the system has a well pump supplying a holding tank, then the pressure and flow through the pump will vary as the holding tank fills up. This variation will be nearly the same for each pump cycle. Since the flow and pressure across the Iodinator will vary the same each time, no operational problems should exist.

Iodinated water at normal use concentrations of 1.0 mg/l, or below, was found to have no discernible taste, odor, or color.

Although access to the Iodinator's location at the Angeles Crest Station was difficult, access to the plumbing itself was easy. No maintenance was required during the test period except for seasonal valve adjustment due to water temperature fluctuations. The total coliform count was zero for each monthly test taken during the test period.

The Iodinator, working in conjunction with the hand pump, performed satisfactorily. When the stroking frequency was raised from 30 to 40 strokes a minute to 80 strokes a minute, the iodine concentration increased from 0.7 to around 1.2 mg/l. The average user of the hand pump will not pump 80 strokes a minute for very long because of exhaustion, so if the Iodinator is set for around 0.7 mg/l at 30 to 40 strokes a minute, the average user should keep the iodine concentration at that level. Some trial-and-error adjustments will be required.

CONCLUSIONS AND RECOMMENDATIONS

The Iodinator produces a constant iodine residual as long as any combination of operational pressure and flow rate remains constant. Assuming a static water supply head, the flow through the Iodinator can be expected to remain constant if the Iodinator is followed by a detention tank equipped with a mechanical or electrical float control assembly. Since variations in water systems complicate requirements, design assistance should be secured from the manufacturer.

Iodine solubility in water is directly proportional to water temperature, so water going through the Iodinator should be protected from temperature variation as much as practicable. If the water supply is subject to seasonal temperature variations, the Iodinator will have to be adjusted to maintain a constant iodine residual. Fortunately, most subsurface water supplies remain fairly constant in temperature all year long.

Desirable disinfectant contact time for most potable water systems is determined by location, degree of contamination, local and State codes, and similar conditions. A minimum 20-min detention time resulting in a 0.5 mg/l free iodine residual is recommended. The bacteria kill resulting from an iodine concentration of 0.5 mg/l occurs in less than half the time when a concentration of 1.0 mg/l is used.

Our tests showed that the Iodinator was accurate up to 40 psi. As already mentioned, Dr. A. P. Black's tests in the penal institutions proved the accuracy of the Iodinator from 40 to 65 psi over a 3-year period.

Our tests using a hand pump showed that large variations in pumping frequency produced small variations in iodine concentration. The manufacturer has adaptor blocks for most types of hand pumps, so if a hand pump is to be used in conjunction with an Iodinator and is not specifically designed for the Iodinator assembly, contact the manufacturer.

According to EPA and prominent endocrinologists across the country, it is safe to iodinate potable water for transient use (a person present 3 weeks or less) at a free residual iodine concentration of 1.0 mg/l or less (appendixes II, III, IV).

A group of endocrinologists are clinically studying a community of people using drinking water from a permanent iodine disinfection system to determine any possible long-term effects of the iodine. Information on this study will be forwarded when available.

We recommend that at the present time the Forest Service stay within the guidelines of EPA and iodinate only those potable water supplies that serve transient users for 3 weeks or less using a free residual iodine concentration of 1.0 mg/l or less.

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APPENDIX I

Human Iodine Intake: Statement of the American Thyroid Association

At the annual meeting of the American Thyroid Association held in St. Louis, Missouri, September 18-21, 1974, the Association adopted the following statement on human iodine intake:

A. T. A. STATEMENT ON HUMAN IODINE INTAKE

The American Thyroid Association takes note of the marked increase in iodine intake by the population of the United States which has occurred over the past 15 years, which is continuing at present, and which promises to increase further in the near future. The Association is concerned that increases of this magnitude may precipitate human disease and that information is not available on which to base solid recommendations of optimal iodine intake. The Association urges that steps be taken by federal agencies and individual investigators and laboratories to obtain the data necessary to make a sound recommendation on optimal limits for human iodine intake.

Committee on Optimum Intake of Iodine

J. A. Pittman, M.D., Chairman
T. H. Oddie, Co-chairman
L. J. DeGroot
D. A. Fisher
P. R. Larsen
Josip Matovinovic
J. M. McKenzie
John B. Stanbury

Letter from James A. Pittman, Jr., M.D., University of Alabama Medical Center

the University of Alabama in Birmingham
the Medical Center / SCHOOL OF MEDICINE / OFFICE OF THE DEAN / November 20, 1974

Mr. Briar Cook
Staff Engineer, Environmental
United States Department of Agriculture
Forest Service
Equipment Development Center
San Dimas, California 91773

Dear Mr. Cook:

Thank you for your letter of November 5, 1974, concerning the 7120 equipment development test, "ED&T 2523 - Water Usage & Waste-water Characterization." In your letter, you request that I give permission to quote me as having expressed my opinion that "using a concentration of 1.0 mg/l or less in the above type installation is acceptable from a health standpoint." I think a more accurate statement would be that some human beings in the United States are currently ingesting in food and drink a total of 1.0 mg/l per day or more, and there is no good evidence at the present moment that this is harmful to them.

On the other hand, we have very little information of any sort on which to base such a statement other than the absence of relatively gross abnormalities of thyroid function. However, as I understand from you, most humans consume something less than a liter of such water in the course of a day (so would ingest only a fraction of a mg of iodine from that source); and since some diseases have been treated in the past with relatively large quantities of iodine (one or more <u>grams</u> per day) without serious abnormalities, it appears to me unlikely that adding a milligram of iodine per liter of drinking water would substantially alter the health status of those using that water as their drinking water.

It is also clear, however, that occasional individuals have pre-existing abnormalities of the thyroid which pre-dispose them to altered thyroid function, particularly reduced function and even myxedema, as a result of prolonged ingestion of large amounts of iodine. Thus, I would certainly agree that people ingesting substantial amounts of iodine over prolonged periods of time should be aware of this possibility, should make their physicians aware of their increased iodine intake, and should perhaps be checked at least annually or more frequently with special attention to their thyroid function.

I would appreciate being kept informed as to the progress of your water iodination program and look forward to hearing from you in the future.

Yours sincerely,

JA Pittman

James A. Pittman, Jr., M.D.
Dean

CC: Dr. Jacob Robbins

Letter from Lewis E. Braverman, M.D., St. Elizabeth's Hospital of Boston

ST. ELIZABETH'S HOSPITAL OF BOSTON

736 Cambridge Street, Boston, Massachusetts 02135 (617) 782-7000

LEWIS E. BRAVERMAN, M.D.
Director, Endocrinology Division

November 18, 1974

Mr. Briar Cook
Staff Engineer, Environmental
Equipment Development Center
United States Department of Agriculture
Forest Service
San Dimas, California 91773

Dear Mr. Cook:

This is in answer to your letter of November 6, 1974 concerning the possible health hazards of using iodinated water as a disinfectant for transient use in recreation areas and small ranger stations in the California area. If one consumes approximately 1,500 cc's of iodinated water a day, then the maximum ingestion of iodide would probably be approximately 1 mg daily. Since the average iodine intake in the United States varies from approximately 250-700 μg daily, this is a definite increase in the iodine content. It is extremely unlikely that the transient use of such iodinated water would pose any hazard. However, continued use of the iodinated water supply could conceivably alter thyroid function in certain susceptible individuals, although this has not as yet been documented.

We are in the process of carrying out a prospective study on the effects of iodinated water supplies on thyroid function in a few towns in New Mexico whose water supply will be iodinated by the Iodinamics Iodinator. This study will, hopefully, begin in the near future providing the necessary details can be worked out with the New Mexico health authorities.

It should be pointed out that a study done by Thomas and his associates published in the Journal of Clinical Endocrinology and Metabolism in 1966 revealed that there were no adverse effects on thyroid function when the water supply of prisons were iodinated to approximately this degree for 1-2 years.

In summary, I do not feel that there is any significant risk in the transient use of iodinated water supplies and that there is probably no significant risk in more permanent use of such supplies. However, the latter question cannot be answered definitively until our prospective study is completed.

If you have any further questions concerning this problem, please do not hesitate to write or call.

Sincerely yours,

Lewis E. Braverman, M.D.
Professor of Medicine
Tufts Medical School

Letter from James H. McDermott, P.E., Environmental Protection Agency

ENVIRONMENTAL PROTECTION AGENCY

AFWS

DATE FEB 20 1973

Use of Iodine for Disinfection of Drinking Water

Directors, Regional Air & Water Programs Divisions
Attention: Water Supply Representatives

We have received a reply to our request to Dr. A. P. Black for additional information on the effect of iodinated water on human consumers, particularly those with thyroid disease and on the unborn child. Copies of the correspondence are attached.

In this correspondence, the evidence indicates that small amounts of iodine (3 to 10 mg) per day can be expected to impair to some degree the production of thyroid hormones. However, it appears that it would take more than a week of exposure to an iodinated water supply to induce symptoms of reduced thyroid function in the few succeptible individuals probably present in every community.

There is also reported evidence of the occasional occurrence of thyroid goiter or thyroid hormone insufficiency in unborn infants of mothers who have ingested excessive amounts of iodine. The smallest reported amount of iodine inducing such an adverse effect is 12 mg daily. The 2 or 3 mg of iodine per day acquired from drinking water would in itself probably not be harmful but it is additive to the total iodine obtained by the mother from other sources.

Short term exposure to an iodinated water supply containing 0.5 to 1.0 mg of iodine per liter should not be harmful. Long term exposure such as in municipal water systems supplying permanent residents in a community may in rare instances have an adverse effect on individual with impaired thyroid function or on the unborn child. Therefore, the use of iodine for treating such supplies bears this risk.

In summary, the opinion of experts in the field indicates that little if any hazard to consumers would exist if disinfection with iodine were practiced on those water supplies where the consumers are transient and use the water for drinking purposes for periods of three weeks or less. Obviously it is likewise safe to use in emergency situations for the same time period or less. Because of the possibility, although rare, that continued consumption of iodinated water may have an adverse effect on individuals with impaired thyroid function or on the unborn child, iodine disinfection of public water supplies with largely permanent populations is not recommended.

James H. McDermott

James H. McDermott, P.E.
Director
Water Supply Division

APPENDIX V

Colorimetric Determination of Iodine and Iodide or Iodate Ion Residuals

The following discussion is taken from a report by A. P. Black and G. P. Whittle (3, p. 489):

"A mixed indicator is employed consisting of leuco crystal violet, 4, 4', 4" methylidynetris (N, N-dimethylaniline), and mercury (II) chloride. This determination is based on the fact that an iodine residual in the presence of mercury (II) chloride rapidly oxidizes the organic indicator molecule to its highly colored dye form, crystal violet. The mercury (II) chloride complexes iodide ion, allowing the reaction to proceed quickly to completion and eliminates interference by monochloramines or other N-chlorocompounds which may be present.

"Interference from free chlorine is eliminated by the addition of a concentrated ammonium salt buffer and the subsequent formation of monochloramine.

"A colorimetric method for the determination of iodide ion, I^-, residuals has been developed employing potassium peroxymonosulfate, $KHSO_5$, first to oxidize the iodide ion to iodine.

"Similarly, the iodate ion (IO_3^-), may be determined colorimetrically by the controlled addition of iodide ions and acid and the resulting production of elemental I_2. The reaction is stoichiometric and the concentration of iodate ion may be related to the iodine liberated.

"Constituents normally present in water do not interfere and temperature has a negligible effect on the range encountered in swimming pool practice.

"Test kits employing the new method are available from at least three American manufacturers:

> Hach Chem. Co., P. O. Box 907, Ames, Iowa 50011; The La Motte Chem. Products Co., Chestertown, Md. 21620; W. A. Taylor & Co., 7300 York Rd., Baltimore, Md. 21204."

Also available from Iodinamics, El Paso, Tex.

APPENDIX VI

The Black-Whittle Iodine-Iodide Test Kit

Iodinamics supplies a Miget Tester (fig. 9) having a comparator block molded entirely from transparent plastic and sealed so that the color standards cannot collect dust and dirt. A thin black plastic mask, which identifies the type of set and values, is placed inside the block so that the numbers cannot be washed or worn off. The back of the block is etched so that no ground glasses are necessary. The comparator block is 3½-in long, 1¼-in wide and 3¾-in high.

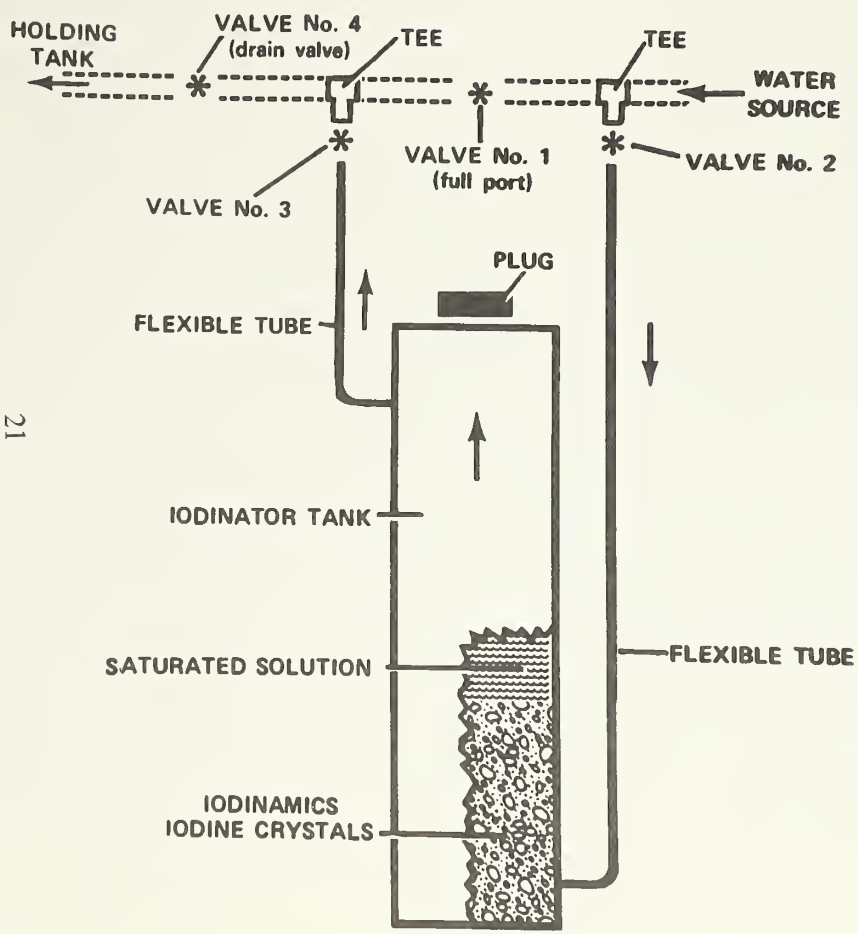
The block contains 8 color standards with values 0.0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.5 and 2.0 ppm. Vials of the following reagents are supplied: B-W Iodine Buffer, B-W Iodine Indicator, Oxone Reagent. Also supplied is a molded plastic cell, a sponge cell cleaner, and instructions.

A residual iodine determination is made by filling the cell to the mark with the water, adding 4 drops B-W Iodine Buffer, mixing for at least 10 sec, adding 4 drops B-W Iodine Indicator and mixing. The treated sample is then compared immediately with the standards by placing the cell in the block and reading the residual iodine from the values on the mask.

Total iodine (iodine plus iodide) is determined by washing the cell well with the water being tested and filling to the mark, adding 4 drops B-W Iodine Buffer, mixing for at least 10 sec, adding 2 drops Oxone Reagent and mixing, after 1 min adding 4 drops B-W Indicator and mixing. The resulting color is then compared with the color standards in the block within 5 min.

Residual iodide is obtained by subtracting free iodine from the total iodine.

Iodinamics Iodinator



INSTALLATION/OPERATING INSTRUCTIONS

1. Install the Iodinamics Iodinator between pump and a holding tank, (pressure tank, storage tank) as near to the pump as possible. If no holding tank exists, it is necessary to install a tank to permit the Iodinator to work efficiently. To determine tank capacity, multiply gpm (gallons per minute) pump rating by 9. Example: 6 gpm pump rating times 9 = 54 gallon holding tank necessary.

2. Remove plug from top of the Iodinator tank; slowly and carefully pour in Iodinamics Iodine Crystals supplied, after reading the label on the Iodine container. Caution: Iodine may stain fabric or stain and irritate skin. To avoid this, rubber gloves should be worn and care taken in handling the material.

3. Completely open valves 1, 2, and 3.

4. Establish the pressure differential necessary by closing full port valve No. 1 approximately one-quarter to one-half turn from the completely open position.

5. Upon initial installation, allow one-half hour for Iodine to go into saturated solution prior to making first residual test. Make first tests from drain valve No. 4, located as close to holding tank as possible.

6. Determine residual Iodine (0.5 ppm – 1.0 ppm) according to the instructions in the Iodinamics Residual Iodine Test Kit provided. Note: There will be no residual Iodine in water samples obtained after a carbon filter.

7. Adjustments. Too much Iodine (more than 1.0 ppm): Open valve No. 1 until desired residual is obtained. Too little Iodine (less than 0.5 ppm): Close valve No. 1 until desired residual is obtained. Make a test the day after installation from the most remote tap in the system. Adjust valve No. 1 as necessary.

   Note: In certain installations, an *existing* pressure differential may be encountered, due to elbows in the line, etc. If so, there is the possiblity that, even with valve No. 1 completely open, greater than necessary residual Iodine will be found. This same occurrence is possible when the service or main line is *below* the Iodinator, creating a siphon action. These situations are easily controlled by making a loop in tubing to at least height of tank. Should additional control be necessary, use the valve on the "Iodine" line, valve No. 3.

8. If sand is present, invert tees and use street ells to return to Iodinator.

9. Check Iodine crystal level in Iodinator tank at least once a year. To do this, close completely valves No. 2 and 3. Open plug slightly to relieve pressure, then remove plug from tank and measure depth of Iodine crystal bed with a ruler or clean rod. Should Iodine bed be 2/3 depleted, replenish with a new supply of Iodinamics Iodine Crystals.

GPO 899-068